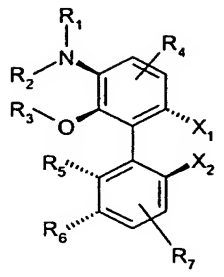
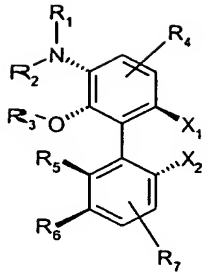
Claims:

1. A compound of the formula Ia or Ib,


(Ia),

(Ib),

where

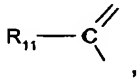
X_1 and X_2 are each, independently of one another, secondary phosphino;

R_1 and R_2 are each, independently of one another, hydrogen, C_1-C_8-alkyl, C_3-C_8-cycloalkyl, C_3-C_8-cycloalkyl-C_1-C_4-alkyl, C_6-C_{10}-aryl or C_7-C_{11}-aralkyl, or

R_1 and R_2 together are C_4-C_8-alkylene, 3-oxapentyl-1,5-ene, $-(CH_2)_2-NH-(CH_2)_2-$ or $-(CH_2)_2-N(C_1-C_4alkyl)-(CH_2)_2-$,

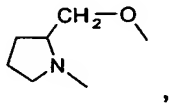
R_3 is hydrogen, C_1-C_8-alkyl, C_3-C_8-cycloalkyl, C_3-C_8-cycloalkyl-C_1-C_4-alkyl, C_6-C_{10}-aryl or C_7-C_{11}-aralkyl, or

R_1 is as defined above and R_2 and R_3 together are C_2-C_8-alkylidene, C_4-C_8-cycloalkylidene, C_1-C_4-alkylene, C_2-C_8-alk-1,2-enyl, -C(O)- or a group of the formula


,

or

R_1R_2N and R_3O together are a group of the formula


,

or

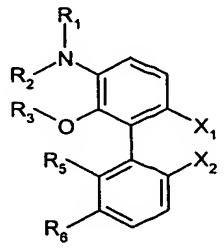
R_1, R_3, or R_1 and R_3 together are a protective group and R_2 is as defined above,

R_4 and R_7 are each, independently of one another, hydrogen, C_1-C_4-alkyl, C_1-C_4-alkoxy, F, Cl or trifluoromethyl,

R_5 is hydrogen, R_4 or an R_3O- group, where R_3O- groups in the two rings can be identical or different,
R_6 is hydrogen, R_7 or an R_1R_2N- group, where R_1R_2N- groups in the two rings can be identical or different,
R_5 and R_6 together are trimethylene, tetramethylene or –CH=CH-CH=CH-,
and
R_{11} is C_1-C_8-alkyl, C_3-C_8-cycloalkyl, C_3-C_8-cycloalkyl-C_1-C_4-alkyl, C_6-C_{10}-aryl or C_7-C_{11}-aralkyl,
where R_1, R_2, R_3, R_4 and R_7 are unsubstituted or substituted by C_1-C_4-alkyl, C_1-C_4-alkoxy, OH, F, Cl, Br, trifluoromethyl, C_1-C_4-hydroxyalkyl, -COOH, $-SO_3H$, $-C(O)O-C_1$-C_4-alkyl, $-SO_3-C_1$-C_4-alkyl, $-C(O)-NH_2$, $-CONHC_1$-C_4-alkyl, $-CON(C_1$-C_4-alkyl$)_2$, $-SO_3-NH_2$, $-SO_2-NHC_1$-C_4-alkyl, $-SO_3-N(C_1$-C_4-alkyl$)_2$, $-O_2C-R_8$, $-O_3S-R_8$, $-NH-(O)C-R_8$, $-NH-O_3S-R_8$, $-NH_2$, $-NHR_9$ or $-NR_9R_{10}$, where R_8 is hydrogen, C_1-C_8-alkyl, C_3-C_8-cycloalkyl, C_3-C_8-cycloalkyl-C_1-C_4-alkyl, C_6-C_{10}-aryl or C_7-C_{11}-aralkyl, and R_9 and R_{10} are each, independently of one another, C_1-C_4-alkyl, phenyl or benzyl or R_9 and R_{10} together are tetramethylene, pentamethylene, 3-oxa-1,5-pentane or $-(CH_2)_2-N(C_1$-C_4-alkyl$)-(CH_2)_2-$.

2. The compound as claimed in claim 1, characterized in that X_1 is a $-P(R)_2$ group and X_2 is a $-P(R')_2$ group, where R and R' are each, independently of one another, an X1/X2-forming radical, for example a hydrocarbon radical which has from 1 to 20 carbon atoms and is unsubstituted or substituted by halogen, C_1-C_6-alkyl, C_1-C_6-haloalkyl, C_1-C_6-alkoxy, C_1-C_6-haloalkoxy, $-CO_2-C_1$-C_6-alkyl, $(C_6H_5)_3Si$ or $(C_1$-C_{12}-alkyl$)_3Si$; or the radicals R and R' together are unsubstituted or C_1-C_4-alkyl- and/or C_1-C_4-alkoxy-substituted tetramethylene or pentamethylene.

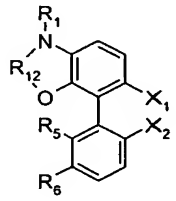
3. The compound as claimed in claim 1, characterized in that it corresponds to the formula Ic,



(Ic)

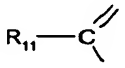
where R_1 is hydrogen or is defined as for R_2, or R_1, R_2 and R_3 are each, independently of one another, C_1-C_4-alkyl, R_5 is hydrogen or an OR_3 group, R_6 is hydrogen or an $-NR_1R_2$ group, or R_5 and R_6 together are
$-CH=CH-CH=CH-$, and X_1 and X_2 are secondary phosphino.

4. The compound as claimed in claim 1, characterized in that it corresponds to the formula Id,



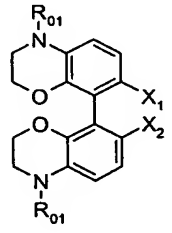
(Id)

where R_1 is hydrogen or C_1-C_4-alkyl, R_5 and R_6 are each hydrogen or R_5 and R_6 together are an $-NR_1-R_{12}-O-$ group, X_1 and X_2 are secondary phosphino and R_{12} is 1,2-ethylene, 1,2-ethenylene, -C(O)- or a group of the formula

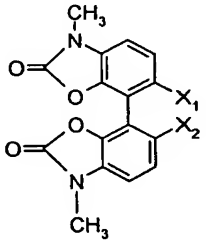


where R_{11} is branched C_3-C_8-alkyl, C_5-C_6-cycloalkyl, phenyl or benzyl.

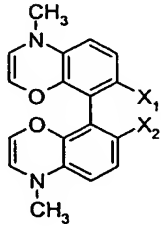
5. The compound as claimed in claim 1, characterized in that it corresponds to the formula Ie, If, Ig, Ih or Ii,



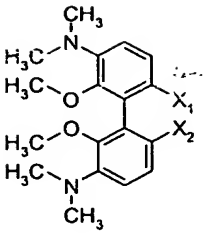
(Ie)

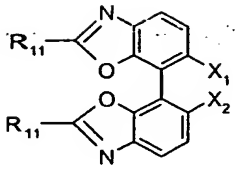


(If)



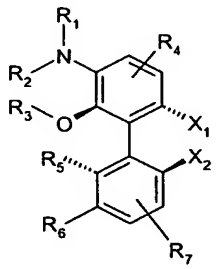
(Ig)

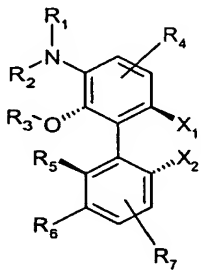

(Ih)


(Ii)

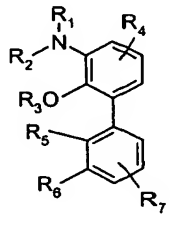
where R_{01} is hydrogen, C_1-C_8-alkyl, C_5-C_6-cycloalkyl, phenyl or benzyl, R_{11} is phenyl or t-butyl and X_1 and X_2 are as defined above, including the preferences.

6. A process for preparing compounds of the formulae Ia and Ib,

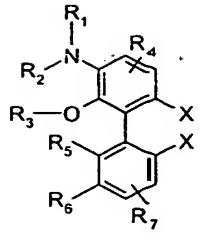

(Ia),


(Ib),

where R_1, R_2, R_3, R_4, R_5, R_6, R_7, X_1 and X_2 are as defined above, which comprises the steps:
a) halogenation of a compound of the formula VI


(VI),

where R_1, R_2, R_3, R_4, R_5, R_6 and R_7 are as defined above, or R_1 is a protective group which can be split off and R_2 is hydrogen or is as defined above, or R_3 is a protective group which can be split off, or R_1 and R_3 form a protective group which can be split off and R_2 is hydrogen or is as defined above, by means of chlorine, bromine or iodine to form a compound of the formula VII

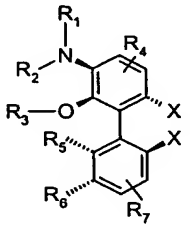


(VII),

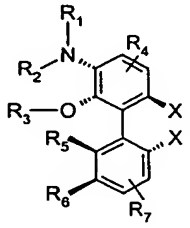
where X is chlorine, bromine or iodine,

b) if appropriate to introduce the radicals R_2 and R_3, removal of the protective groups to form OH-functional and NH-functional groups and replacement of the H atoms in the OH-functional and NH-functional groups by means of a reagent R_2-Y_2, R_3-Y_2 or Y_2-R_{13}-Y_2, where Y_2 is a leaving group and R_{13} is 1,2-alkylene or 1,2-cycloalkylene, to produce compounds of the formula VII, and

if appropriate resolution of the racemates of the formula VII to give the enantiomers of the formulae VIIa and VIIb

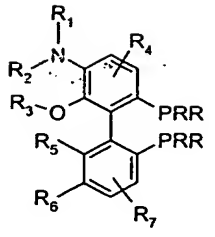
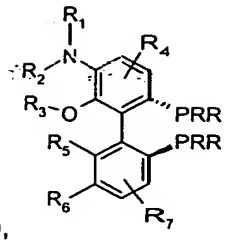
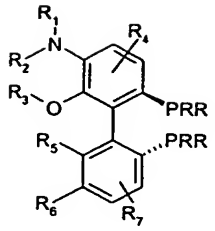


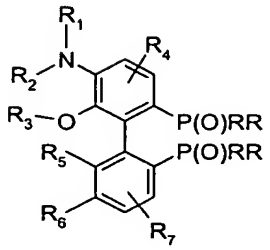
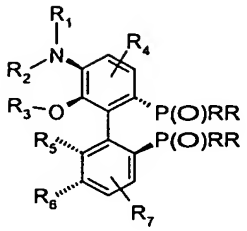
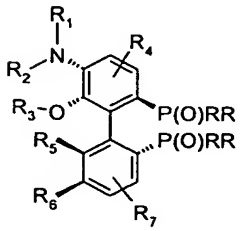
VIIa

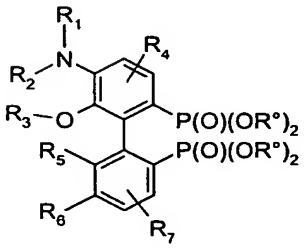
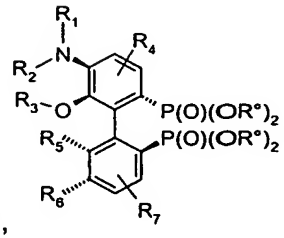
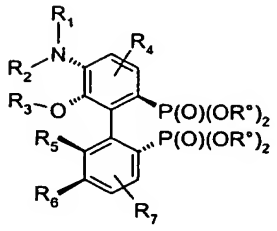


VIIb

c) metalation of the compounds of the formula VII, VIIa or VIIb, for example by means of a lithium alkyl, and subsequent reaction with a halophosphine of the formula X_3-PRR (X_3 is halogen) in the presence of a lithium alkyl to give diphosphines of the formula VIII, Ia or Ib, or with a halophosphine oxide of the formula X_3-P(O)RR to give diphosphine oxides of the formula IX, IXa or IXb, or with a phosphonate of the formula X_3-P(O)(OR°)$_2$ to give phosphonates of the formula X, Xa or Xb:


(VIII),

(Ia),

(Ib),


(IX),

(IXa)

(IXb),


(X),

(Xa),

(Xb),

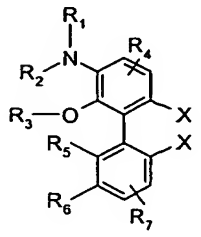
where R is a radical forming X_1/X_2, for example a hydrocarbon radical having from 1 to 20 carbon atoms and R° is C_1-C_6-alkyl or phenyl,

d) if a racemic starting material of the formula VII is used, oxidation of the phosphine groups in compounds of the formula VIII, VIIIa or VIIIb by means of an oxidant to form compounds of the formula IX, IXa or IXb,

e) resolution of the racemates of the formula VIII to give the enantiomers Ia and Ib, or resolution of the racemates of the formula IX to give the enantiomers of the formulae IXa and IXb, or resolution of the racemates of the formula X to give the enantiomers of the formulae Xa and Xb, and reaction of compounds of the formulae Xa and Xb with R-Mg-X to form phosphine oxides of the formula IXa and IXb, and

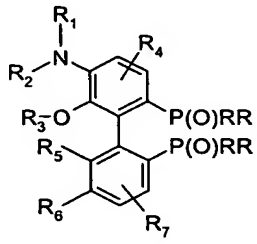
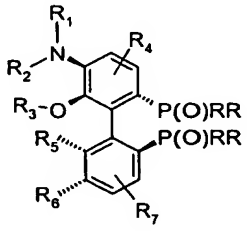
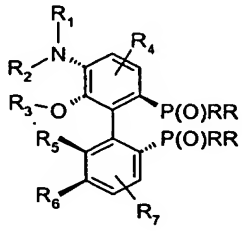
f) reduction of the phosphine oxide group in the compounds of the formulae Xa and Xb to produce compounds of the formulae Ia and Ib.

7. A compound of the formula VII in the form of the racemate, a mixture of diastereomers, a pure diastereomer or an enantiomer in optically enriched or optically pure form,

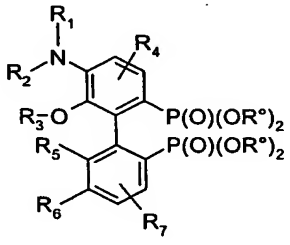
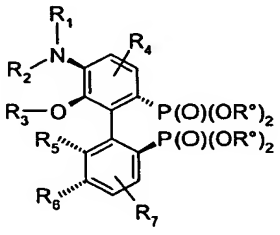
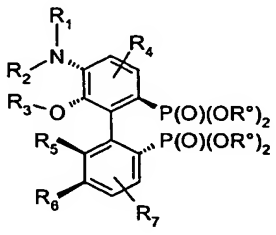

(VII),

where R_1, R_2, R_3, R_4, R_5, R_6 and R_7 are as defined in claim 1, or
R_2 is a protective group which can be split off or R_2 and R_3 together form a protective group which can be split off and R_1, R_3, R_4, R_5, R_6 and R_7 or R_1, R_4, R_5, R_6 and R_7 are as defined in claim 1, and
X is chlorine, bromine or iodine.

8. A compound of the formula IX (racemate) or a compound of the formula IXa and/or IXb (mixture of diastereomers, a pure diastereomer or an enantiomer in optically enriched or optically pure form),


(IX),

(IXa),

(IXb),

or a preproduct of the formula X (racemate) or a compound of the formula Xa and/or Xb (mixture of diastereomers, a pure diastereomer or an enantiomer in optically enriched or optically pure form),


(X),

(Xa),

(Xb)

where R_1, R_2, R_3, R_4, R_5, R_6, R_7 have the meanings indicated for the compounds of the formulae I and Ia, including the preferences, R^o is C_1-C_6-alkyl or phenyl and R is an X_1/X_2-forming radical, for example a hydrocarbon radical having from 1 to 20 carbon atoms.

9. A complex of a metal selected from the group of the TM8 metals with a compound of the formula Ia or Ib as claimed in claim 1 as ligand.

10. The metal complex as claimed in claim 9 which corresponds to the general formula XI or XII,

A_1MeL_n (XI), $(A_1MeL_n)^{(z+)}(E^-)_z$ (XII),

where A_1 is a compound of the formula Ia or Ib as claimed in claim 1;
L represents identical or different monodentate, anionic or nonionic ligands, or two L form identical or different bidentate, anionic or nonionic ligands;
n is 2, 3 or 4 when L is a monodentate ligand or n is 1 or 2 when L is a bidentate ligand;
z is 1, 2 or 3;
Me is a metal selected from the group consisting of Rh and Ir; with the metal having the oxidation state 0, 1, 2, 3 or 4;
E^- is the anion of an oxo acid or complex acid; and
the anionic ligands balance the charge of the oxidation stage 1, 2, 3 or 4 of the metal.

11. The metal complex as claimed in claim 9 which corresponds to the formula XIII or XIV,

$[A_1Me_1YZ]$ (XIII), $[A_1Me_1Y]^+E_1^-$ (XIV),

where
A_1 is a compound of the formula Ia or Ib as claimed in claim 1;
Me_1 is rhodium or iridium;
Y represents two olefins or one diene;
Z is Cl, Br or I; and
E_1^- is the anion of an oxo acid or complex acid.

12. A process for preparing chiral organic compounds by assymetric addition of hydrogen, boron hydrides or silanes onto a carbon-carbon or carbon-heteroatom multiple bond in

prochiral organic compounds, or the asymmetric addition of carbon nucleophiles, alcohols or amines onto allyl compounds in the presence of a catalyst, characterized in that the addition reaction is carried out in the presence of catalytic amounts of at least one metal complex as claimed in claim 9.

13. The use of the metal complexes as claimed in claim 9 as homogeneous catalysts for preparing chiral organic compounds by asymmetric addition of hydrogen, boron hydrides or silanes onto a carbon-carbon or carbon-heteroatom multiple bond in prochiral organic compounds, or the asymmetric addition of carbon nucleophiles or amines onto allyl compounds.